Project Report: Miniature Mass Spectrometer Development

Project Investigator:	***F. Scott Anderson***

Project Progress

The NAI has allowed us to collaborate with Steven Smith at the Jet Propulsion Laboratory to expand development of a miniature mass–spectrometer that is well suited for measuring liquid water directly. The mass spectrometer is <5' in size (Fig. 1), is optimized for detecting heavy organic molecules (50–500K Da), can withstand ballistic emplacement (currently demonstrated to 1200g), operates at pressures as high as several Torr (consistent, for example, with surface pressures on Mars), and has simple electronics. These traits make the instrument uniquely relevant for astrobiology applications such as the detection of key organic biomarkers derived from cellular components as well as geochemical environmental characterization on wet or icy bodies throughout the solar system. The ionizer uses a modified electrospray introduced directly to vacuum (Fig. 2), and the spectrometer itself performs as a momentum filter using rotating radio frequency (RF) fields applied to four poles. The ion spray characteristics are currently undergoing extensive characterization in our laboratory test stand (Fig. 3), developed in part through support of the NAI. We have leveraged NAI funding with both NASA Mars Instrument Development (MIDP) and Department of Defense (DOD) Measurement and Signals Intelligence (MASINT) funds. To date we have acquired the test stand, built the vacuum system, built the electrospray ionizer and mass spectrometer, and have begun testing electrospray under a range of high voltage and vacuum regimes. We will present our initial results at the BioAstronomy Conference this year. We anticipate that we will complete characterization of the electrospray ionizer during the first year of effort, and that in year two we will characterize the momentum filter. In later years we plan to test this system in lacustrine and icy environments.

Figure 1. Prototype mass spectrometer, including four aiming elements, four RF elements, and a faraday cup analyzer. Length is ~ 4".

Figure 2. The electrospray to vacuum ionizer. The charged spray is generated from a electrical element inside of the spray needle visible here. Needle length ~1".

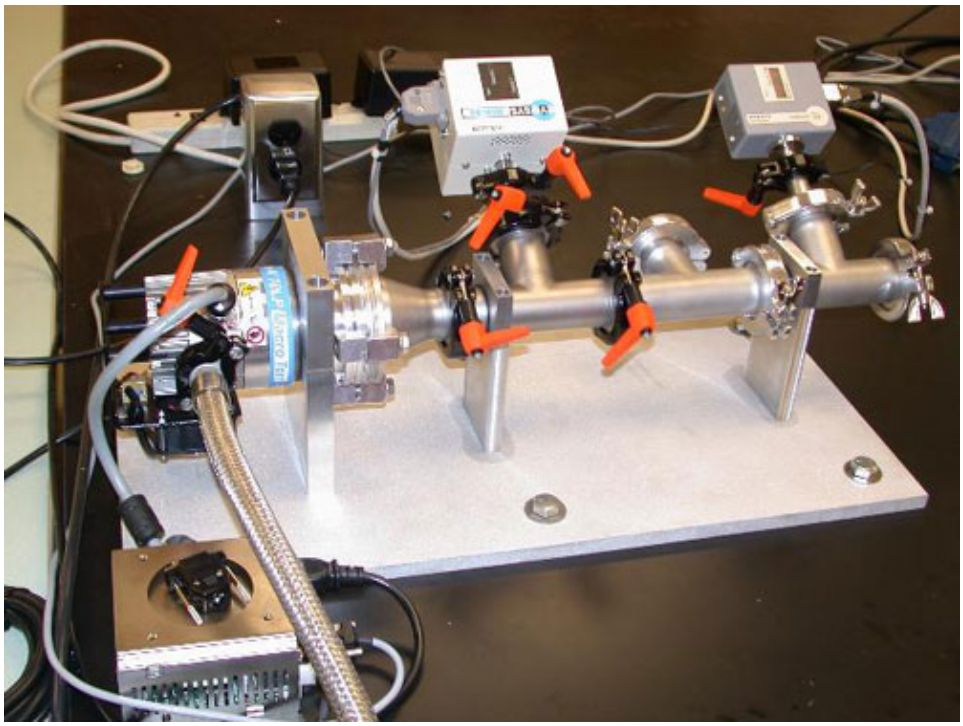

Figure 3. Laboratory vacuum system and test stand designed to accommodate the electrospray ionizer and mass spectrometer. The Mass Spectrometer (Figure 2) fits entirely in the rightmost "T", and the electrospray ionizer attached to the right end of the rightmost "T". The system can attain and accurately measure vacuum from 760 Torr to 10−7 Torr.

Highlights

- Obtained NASA and DOD funding that leverage UH−NAI grant personnel to design, construct, and test a prototype laboratory instrument for direct mass spectral analysis of liquids.
- Built initial laboratory prototype and demonstrated ionization at low vacuum (~3 Torr).
- Initial design presented at BioAst, 2004.

Roadmap Objectives

- ***Objective No. 7.1:*** Biosignatures to be sought in Solar System materials